3 Philosophy, policies, procedures and practices: The four 'P's of flight deck operations

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Introduction

Background

A complex human–machine system is more than merely one or more operators and a collection of hardware components. To operate a complex system successfully, the human–machine system must be supported by an organizational infrastructure of operating concepts, rules, guidelines and documents. The coherency, in terms of consistency and logic, of such operating concepts is vitally important for the efficiency and safety aspect of any complex system.

In high-risk endeavours such as aircraft operations, space flight, nuclear power, chemical production and military operations, it is essential that such support be flawless, as the price of deviations can be high. When operating rules are not adhered to, or the rules are inadequate for the task at hand, not only will the system's goals be thwarted, but there may be tragic human and material consequences. Even a cursory examination of accident and incident reports from any domain of operations will confirm this.

To ensure safe and predictable operations, support to the operators often comes in the form of Standard Operating Procedures (SOP). These provide the crew with step-by-step guidance for carrying out their operations. SOPs do indeed promote uniformity, but they do it at the risk of reducing the role of the human operators to a lower level. Furthermore, an exhaustive set of procedures do not absolutely ensure flawless system behaviour: deviations from SOP have occurred even in highly procedurized organizations.

The system designers and operational management must occupy a middle ground: operations of high-risk systems cannot be left to the whim of the individual. But they likewise must recognize the danger of overproceduralization, which fails to exploit one of the most valuable assets in the system, the operator who is close to the actual operation. Furthermore, the alert system designer and operations manager recognize that there cannot be a procedure for everything, and the time will come when the operators of a complex system face a unique situation for which there is no procedure. It is at this point that we recognize the reason for keeping humans in the system; since automation, with all its advantages, is merely a set of coded procedures executed by the machine. Procedures, whether executed by humans or machines have their place, but so does human cognition.

A dramatic example was provided by the Sioux City accident in which a United Airlines DC-10 suffered a total loss of hydraulic systems, and hence aircraft control, due to a disintegration of the centre engine fan disc (NTSB, 1990a). When he had sized up the situation, the captain turned to the flight engineer and asked what the procedure was for controlling the aircraft. The reply is worth remembering: 'There is none.' Human ingenuity and resource management were required: the crew used unorthodox methods to control the aircraft. This resulted in a crash landing, which well over half of the passengers and crew survived.

This chapter is a continuation of our previous work on the human factors of aircraft checklists in air carrier operations (Degani and Wiener, 1990). Our work in this area was undertaken largely as a result of the discovery, during the investigation of the Northwest 255 crash, that checklists, for all their importance to safe operation, had somehow escaped the scrutiny of the human factors profession. The same, we found out, can be said of most flight deck procedures. We felt that our work in checklist design and usage would not be complete until we gave equal consideration to cockpit procedures.

Procedural deviation: Its influence on safety

Problems within the human-procedure context usually manifest themselves in procedural deviation. If all goes well, these deviations are not apparent to the operational management, and in most cases are left unresolved. They do become apparent, however, following an incident or an accident. Lautman and Gallimore (1988) conducted a study of jet-transport aircraft accident reports to 'better understand accident cause

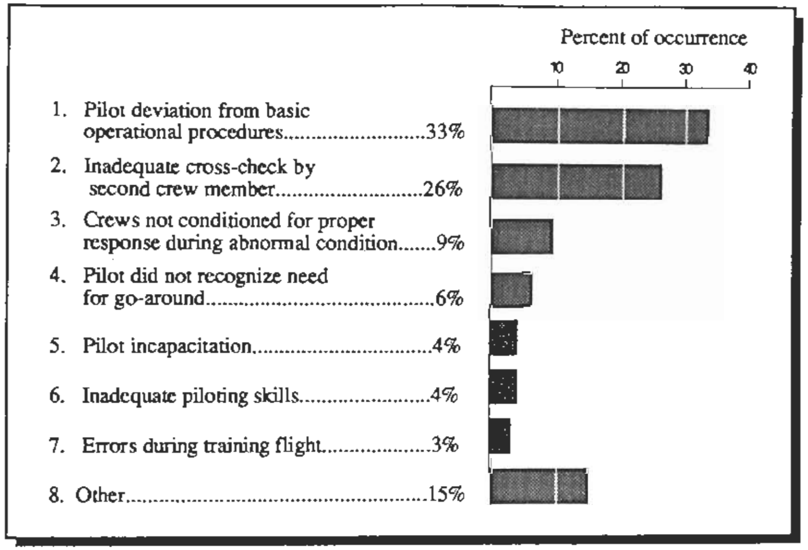

Figure 3.1 Significant crew-caused factors in 93 hull-loss accidents
(Source: Adapted from Lautman and Gallimore, 1988)

factors' in commercial airline operations. They analysed 93 turbojet hull-loss accidents that occurred between 1977–1984.

The leading crew-caused factor in their sample was 'pilot deviation from basic operational procedures' (Figure 3.1). These findings are clearly supported by three airline accidents that occurred in the last five years: in the first, Northwest Airlines Flight 255, an MD-82, crashed shortly after take-off from Detroit Metro Airport following a no-flap/no-slat take-off (NTSB, 1988). In the second, Delta Air Lines Flight 1141, a B-727, crashed shortly after lifting off from Dallas–Fort Worth International Airport, following a no-flap/no-slat take-off (NTSB, 1989). In the third, USAir Flight 5050, a B-737, ran off the runway at LaGuardia Airport and dropped into adjacent waters, following a mis-set rudder trim and several other problems (NTSB, 1990b).

We submit that the classification of 'pilot deviation from basic operational procedures' may be somewhat misleading. One should first ask whether the procedures (from which the flight crews deviated) were adequate for the task. Were the procedures compatible with the operating environment? Were they part of a consistent and logical set of procedures? Most important, was there something in the design or the manner in which the procedure was taught that led a responsible flight crew member to deviate from it?

We argue that if we wish to understand how operators conduct flight deck procedures, we cannot look only at the aggregate level, i.e. procedures, but we also must examine the infrastructure, i.e. the policies and concepts of operation, that are the basis on which procedures are developed, taught and used.

Theory of the three 'P's: Philosophy, Policy and Procedures

Procedure development

Procedures do not fall from the sky, nor are they inherent in the equipment. Procedures must be based on a broad concept of the user's operation. These operating concepts lend themselves into a set of work policies and procedures that specify how to operate the equipment efficiently. There is a link between procedures and the concepts of operations. We call that link 'The three 'P's of cockpit operations': philosophy, policies and procedures. In this chapter we shall explore the nature of these links, and how an orderly, consistent path can be constructed from the company's most basic philosophy of operation to the actual conduct of any given procedure.

Procedures: What and Why? In general, procedures exist to specify unambiguously six things:

1 What the task is.
2 When the task is conducted (time and sequence).
3 By whom it is conducted.
4 How the task is done (actions).
5 The sequence of actions.
6 What type of feedback is given (callout, actions etc.).

The function of a well-designed procedure is to aid the operators by dictating and specifying a progression of sub-tasks and actions to ensure that the primary task at hand will be carried out in a manner that is efficient, logical and also error resistant. Another important function of a cockpit procedure is that it should enhance coordination between agents in the system, be they cockpit crew, cabin crew, ground crew, or others. Procedures are also a form of quality control by management and regulating agencies over the operators.

Standard operating procedures A set of procedures that apart from being merely a specification of a task, also serve to provide a common ground for two or three individuals (comprising a flight crew) that at times may be totally unfamiliar with each other's experience and technical capabilities. So strong is the airline industry's belief in SOPs that it is believed that in a well standardized operation, in mid-flight a cockpit crew member could be plucked from the cockpit and replaced with another and the operation would continue safely and smoothly.

As mergers and acquisitions create 'mega-carriers', the process of standardization, and the need to render consistent and unambiguous manuals, procedures, policies, and philosophies becomes increasingly important, costly and difficult to achieve. This is because not all flight crews equally share the corporate history and culture that lead to a certain concept of operation. Nevertheless, any operator knows that adherence to SOPs is not the only way to operate a piece of equipment; and that there are several other ways of doing the same task with reasonable level of safety (Orlady, 1989). For example, most carriers require that crews enter the magnetic course of the runway into the heading select window on the Mode Control Panel (MCP) before take-off. One company requires that the first published or expected heading after take-off be entered. Good reasons exist for both procedures.

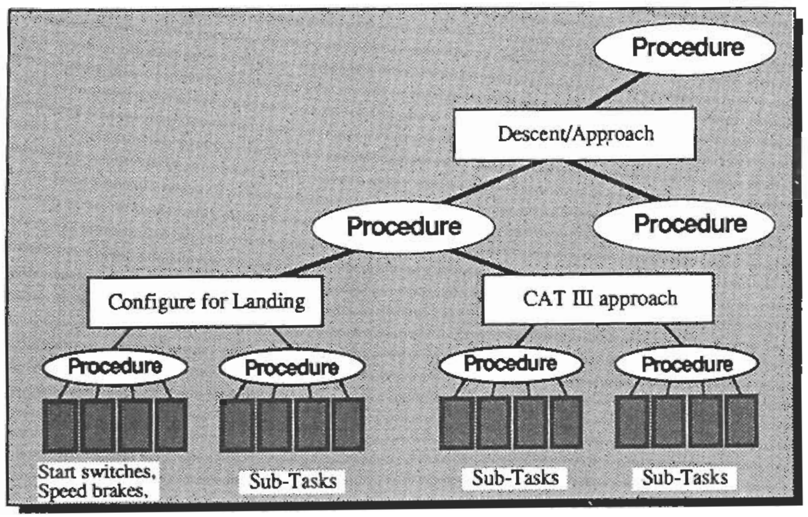

Figure 3.2 The task-procedure framework

Tasks and procedures As mentioned earlier, it is common in all high-risk systems that critical tasks that affect the objectives of the system are always accompanied with a set of procedures. Procedures, in turn, specify a set of sub-tasks or actions to be completed; that is, each procedure can be shown to lie between a higher level task and lower level sub-tasks. Figure 3.2 shows this structure. The structure, or pyramid, ends with the system goal, e.g. flying passengers from point A to point B.

The task-procedure hierarchy allows one to make the distinction between a checklist and a procedure (as the two are often confused). A checklist is a device (paper, mechanical, audio or electronic format), that exists to ensure that certain actions are carried out. A checklist is not, however, a procedure *per se*. The confusion may arise from the fact that conducting the checklist procedure is a task which is specified by a higher level procedure (e.g. 'the *taxi checklist* shall be conducted once the aircraft starts to move on its own power').

Philosophy and policies

Philosophy The cornerstone of our approach to the concepts of cockpit procedures is philosophy. By philosophy we mean that the airline management determines an over-arching view of how they will conduct the business of the airline, including flight operations. A company's philosophy is largely influenced by the individual philosophies of the top decision makers, but also by the company's culture, a term that has come into favour in recent years in explaining broad-scale differences between corporations. The corporate culture permeates the company, and a philosophy of flight operations emerges. (For a discussion of cultural differences between carriers, see various chapters in Wiener *et al.*, 1993.)

Although most airline managers, when asked, cannot clearly state their philosophy, such philosophies of operation do indeed exist within airlines. They can be inferred from procedures, policies, training, punitive actions, etc. For example, one company that we surveyed had a flight operation philosophy of granting considerable discretion (they called it 'wide latitude') to the individual pilot. Pilots are schooled under the concept that they are both qualified and trained to perform all tasks. Consistent with this philosophy, the company until recently allowed the first officer to call for as well as conduct the rejected take-off (RTO) manœuvre (a manœuvre which is only at the captain's discretion at most carriers).

The emergence of flight deck automation as an operational problem has recently generated an interest in the philosophy of operations, partly due to lack of agreement about how and when automatic features are to be used, and who may make that decision (Wiener, 1989). This led one carrier, Delta Air Lines, to develop a one-page formal statement of automation philosophy (see Appendix 1). This philosophy is discussed by Wiener *et al.* (1991). It is the first case that we are aware of where an airline management actually wrote out its philosophy and the consequences of its philosophy on doing business.

Policies The philosophy of operations, in combination with economic factors, public relations campaigns, new generations of aircraft, and major organizational changes, generates policies. Policies are broad specifications of the manner in which management expects operations to be performed (training, flying, maintenance, exercise of authority, personal conduct, etc.). Procedures, then, should be designed to be as consistent as possible with the policies (which are consistent with the philosophy). Figure 3.3 depicts this framework.

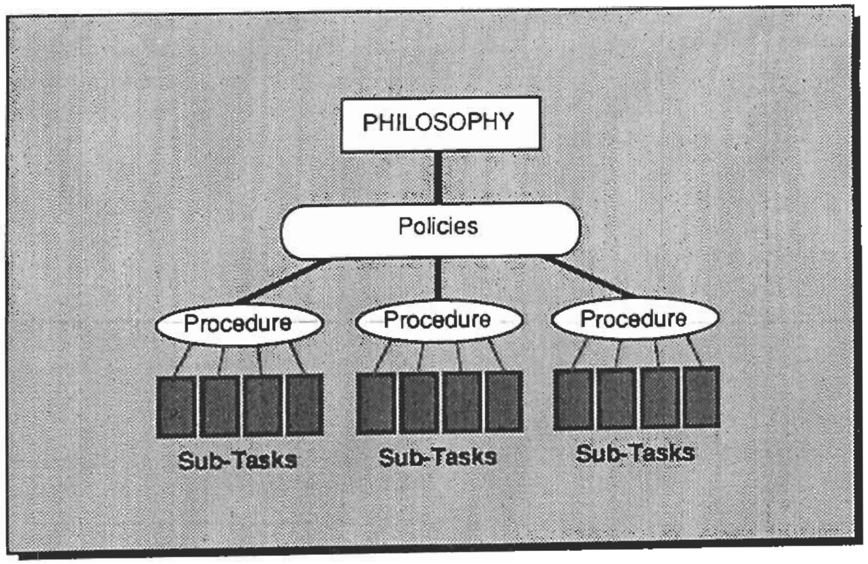

Figure 3.3 The three 'P's

The levels in the three 'P's framework are not rigid. For some aspects of flight operations there may be several policies, for others there may be only a philosophy. For example, checklist SOP is a mature aspect of flight operation: there may be an overall checklist philosophy, checklist policies for normal, abnormal and emergency situations. Flight deck automation' is still an immature aspect; in this case, there may be only a philosophy and procedures. As the operation becomes more mature, policies are defined and added. Philosophies may also change with time.

To illustrate the three 'P's, let us assume that the task at hand is the configuration of an advanced technology aircraft for a Category-I ILS approach:

1 *Philosophy*: Automation is just another tool to help the pilot.
2 *Policy*: Use or non-use of automatic features (within reason) is at the discretion of the crew.
3 *Procedure*: On a Category-I approach, the flight crew will first decide what level of automation to use (hand-fly with flight director; autopilot and mode control panel; coupled; etc.), which determines what must be done to configure the cockpit.
4 *Sub-tasks (or actions)*: Follow from procedures (e.g. tune and identify localizer and compass locator, set decision height, select autopilot mode, etc.). ,

Consider the following example of how policies that are actually remote from flight operations can affect procedures. One carrier's new public relations policy called for more interaction between the cockpit crew and the passengers. It was recommended that at each destination the captain stand at the cockpit door and make farewells to the passengers as they departed the cabin. This dictated a change in the procedure that most of the *secure-aircraft* checklist will be done by the first officer. Thus checklist procedures which would normally be run by both pilots, probably as a challenge-and-response, yielded to public relations to be performed by a single pilot. The marketing department considered this particularly important, as they wanted the captain to he in place at the cockpit door in time to greet the disembarking first-class passengers.

To conclude, it is our position that procedures should not (1) come solely from the equipment supplier, or (2) simply be written by the individual fleet manager responsible for the operation of the specific aircraft. They must be based on the operational concept of the organization, and on the organization's examination of its own philosophies. We hypothesize that if procedures are developed in this manner, and a logical and consistent set of cockpit SOPs are thus generated, that there will be a higher degree of conformity during line operations, flight training will improve, and the general quality of flight operations will be enhanced.

If flight management attempts to shortcut the three 'P's process by jumping right into procedure writing, the risk is a set of ill-conceived and inconsistent procedures.

The fourth 'P': Practices

An extension of the three 'P's

In the first two sections of this chapter we focused on the global aspects of flight operations: the philosophy, policies and procedures (Degani and Wiener, 1991). As we progressed in this research, it appeared to us that something was missing. We neglected and ignored the ultimate consumer of the procedure – the pilot– whose decisions and actions determine the 'system outcome'.

To correct this, we have added an additional component – practices. A practice is the activity actually conducted on the flight deck. While procedures must be part of a structured framework, it is the crew members who must carry them out. It is the pilot who will either conform to a procedure or deviate from it. The procedure is specified by management – the practice is conducted by the crew. Ideally they should be the same. The high prevalence of the 'pilot deviation from SOP' classification (Lautman and Gallimore, 1988) indicates that no one can assume that operators will always follow any given procedure dictated by flight management.

The goal of flight management is to promote 'good' practices by specifying coherent procedures. But we must also recognize that this is not always the case – procedures may be designed poorly. The crew can either conform to a procedure or deviate from it. The deviation may be trivial (e.g. superimposing some non-standard language on a procedural callout), or it may be significant (e.g. not setting the auto-brakes according to the take-off procedures). The alternatives of conformity *versus* deviation can be visualized as a switch (Figure 3.4). This may be somewhat of an over-simplification, but it expresses the choice that the crew member must make: to conform or to deviate. The reasons for and consequences of 'placing the switch' in the 'deviate' position will be explored later in this chapter.

We envision a term '$\triangle$' – delta, or the degree of difference between procedures and practices (Figure 3.5). This '$\triangle$' (not to be interpreted as a quantitative value by any means) expresses the amount of deviation from a specified procedure. This term has two components: (1) the magnitude of deviation from the procedure, and (2) the frequency of such deviations during actual line operations. The goal of flight management is to minimize $\triangle$. When $\triangle$ is large (flight crews constantly deviate from SOP and/or deviate in a gross manner) there is a problem. It may be due to a culprit crew, or in the case where there are frequent violations by many flight crews, a problem in the procedure itself.

The pilot, in this situation, is analogous to a 'filter'. From the above, standards and training departments dictate and teach the way procedures

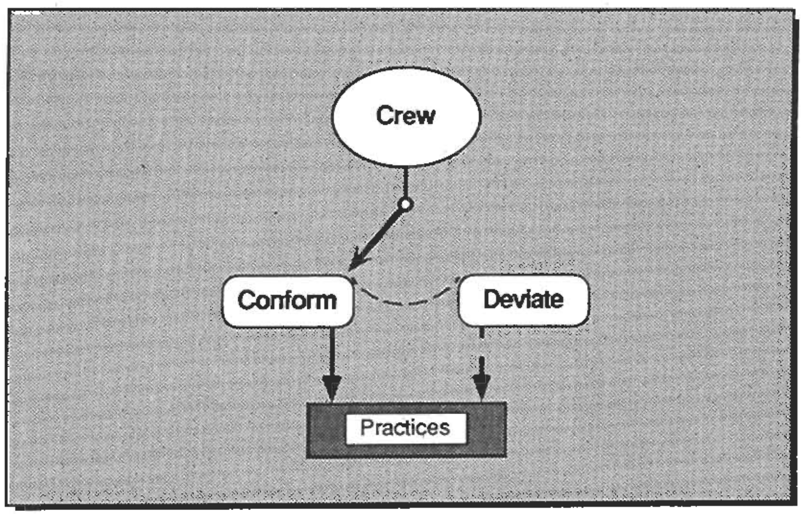

Figure 3.4 The deviate versus conform 'switch'

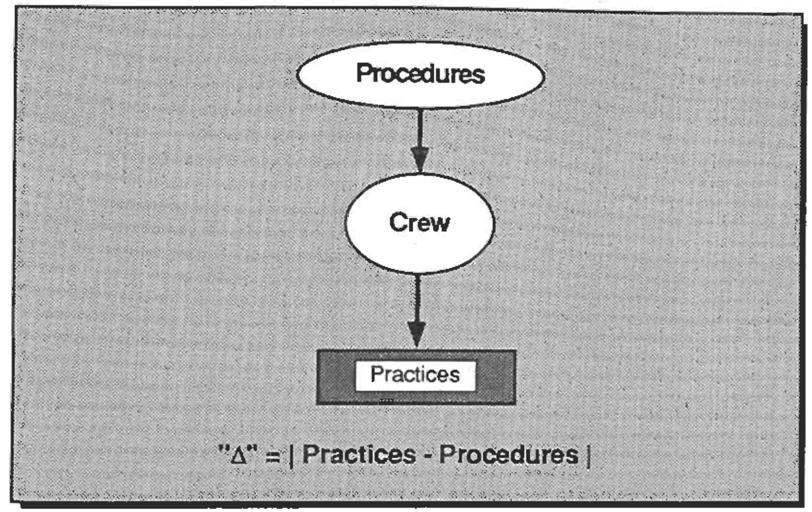

Figure 3.5 The quantity '$\triangle$' – deviation from procedures

should be performed. However, in daily line operations (and not under the watchful eye of a check-airman), the individual pilot may adjust the gauge of the filter. This gauge will determine just how much of the SOPs will be actually used, modified, misused or completely unused. The process and the purpose of standardization is to bias the filter towards prevention of deviations.

The consequences of the failure to conform to a procedure can be seen in the following report from NASA's Aviation Safety Reporting System (ASRS) (note that ASRS reports included in this chapter are quoted verbatim):

> The flight was delayed approximately 2 hours due to late arrival of outbound aircraft. F/O arrived and observed how 'tired' he was since he had done 'yard work' all day at home. Our flight finally departed late PM local time for the 4:30 plus flight to SFO. F/O was PF. En route discussed necessity to request lower altitudes with both OAK CTR and Bay Approach when approaching SFO due to tendency to be 'caught high' on arrival in this aircraft type. Area arrival progressed smoothly and we were cleared for the QUIET BRIDGE visual to 28R. When changing radio frequency from approach to tower (head down), F/O selected 'open descent' to 400 feet MSL. Autopilot was off, both flight directors were engaged, and autothrust was on. While contacting SFO tower I became aware that we were below the glideslope, that airspeed was decaying, and that we were in an 'open descent'. Instructed the F/O to engage the V/S mode in order to stop our descent, restore the speed mode for the autothrust, and continue the approach visually once above the 28R ILS glideslope. Company procedures explicitly prohibit selecting an altitude below 1500 feet AGL for an open descent, since this places the aircraft close to the ground with engines at idle. I attempted to explain to the F/O when we were parked at the gate that he had configured the aircraft improperly. Lack of adherence to SOP: 'highly automated' aircraft demands explicit following of established procedures. Unfortunately, it is possible to fly the aircraft numerous ways that will degrade your safety margin rapidly. Adherence to procedures would have prevented this incident (ASRS Report No. 149672).

To summarize, the ultimate factor that determines the quality of the system outcome is the actual practices. These may be governed by procedures, but they are not the procedures themselves. Management's role does not end with the design of the procedure. Management must maintain an active involvement as the procedures move from the flight management offices to the line, remaining concerned with practices, and committed to management of quality through reduction of Δ. This is generally approached as a 'standardization', a form of quality management aimed at ensuring compliance. Standardization is also a check on the quality of the procedures themselves, as well as on the training function.

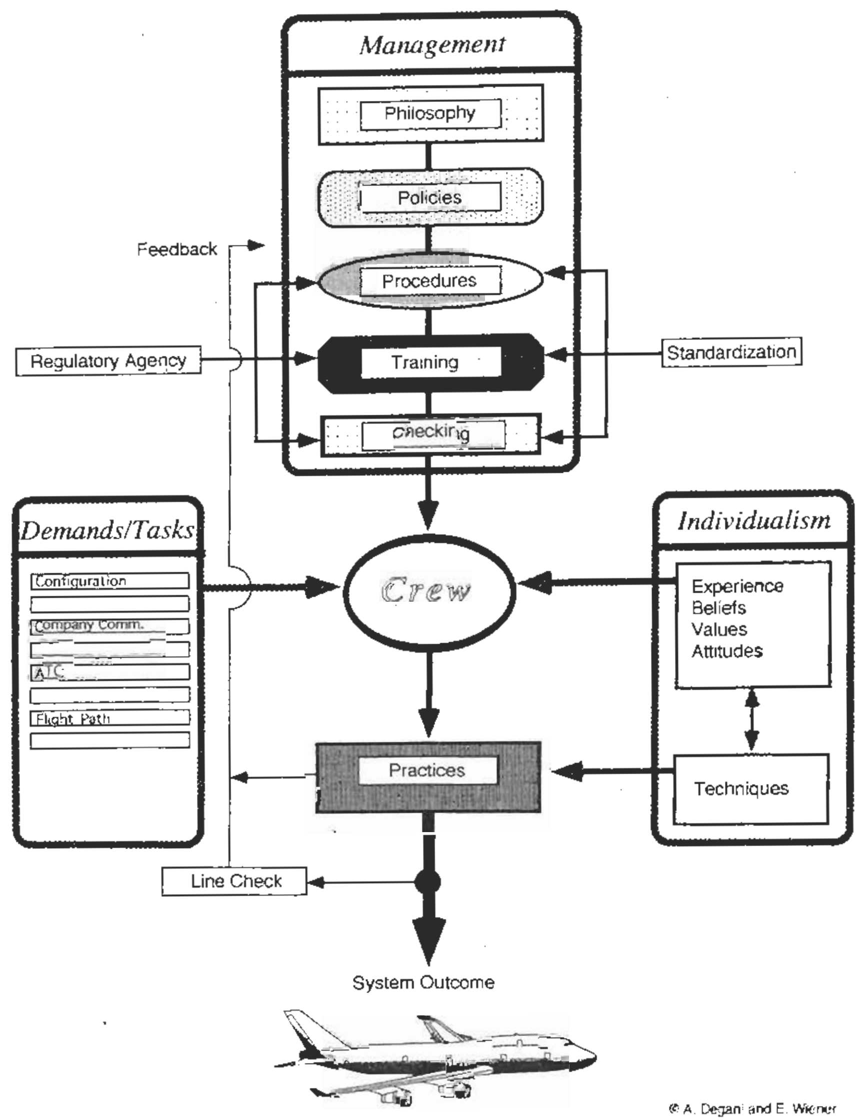

Figure 3.6 Schematic linking all four 'P's

Features of the four 'P's framework

Our four 'P' framework is an extension of the three 'P' framework, taking into account the following: tasks, crews, practices, quality assurance and the system outcome. Figure 3.6 is a global depiction of the inter-relationship of these elements. The top half of the chart is essentially the same as Figure 3.3. But when we get to the circle 'crew' we open the door to *practices* (and △).

Deviant behaviour In this section we shall examine several reasons why △ exists. Why would a well-trained, and presumably well-motivated pilot, purposely deviate from the company's published procedures? Listed below are a few of the reasons.

- *Individualism.* △ arises primarily due to the fact that pilots are individuals, and in spite of training, loyalty and generally a devotion to safe practices, they will impose their individuality on a procedure. This may or may not adversely affect the system. We also recognize that there is a positive side to individualism: it is one of the differences between humans and computers. Individualism makes life interesting and provides us with an incentive to achieve. Pilots are not 'procedure executers': they are individuals who bring to their job certain biases, prejudices, opinions and self-concepts. Furthermore, humans possess brains that allow great flexibility, and this can become critically important in extreme cases where no procedure is available, e.g. United's Sioux City accident, previously mentioned (NTSB, 1990a). The problem is the potential conflict between individualism and standardization in high-risk enterprises.

  We once observed a captain making a altitude change (FL370 to FL 260). He abandoned the already programmed VNAV mode in favour of the V/S mode. Asked why he preferred to disengage VNAV he said: 'just because its fun to have "manual" control over the aircraft.'
- *Complacency.* It is well established in aviation that a pilot's vigilance may not always remain at its highest, or even an acceptable level at all time. This phenomenon, of dropping one's guard, is generally labeled 'complacency'. Wiener (1981) has questioned whether the term has any real meaning, and whether its use makes any real contribution to understanding safety. Pending an answer to this question, it seems safe to say that complacency, as the term is used, may be responsible for many departures from SOP.

  It is the very safety of the system that may generate complacency and non-adherence to SOPs. If day after day, year after year, pilots encounter few threats, and few genuine emergency situations, the temptation to ease up and accept less than standard performance is understandable. Recent work by Parasuraman and his collaborators have examined what they call 'automation complacency', the tendency to become overly trustful and over-dependent on various automatic devices in the cockpit (Parasuraman *et al.*, 1991). Again, it is the unerring quality, the high reliability of these devices, that may induce pilot complacency.
- *Humour.* Humour is closely related to individualism, while its negative consequence may be related to complacency. Humour in the cockpit represents the desire to inject some variety and stimulation into an otherwise humourless situation. Humour, like individualism, has its place. It makes life enjoyable, overcomes the tedium of a highly precise job, and establishes a form of communication between crew members. It also carries potential hazards – it can be at odds with standardization.

  We have observed in checklist reading behaviour, for example, when the pilot reads 'gasoline' where the checklist requires a challenge of 'fuel', or the use of the Spanish term 'unomas' instead of 1000 ft to level-off callout. These departures are inevitable, as they break the monotony of a highly standardized and procedurized situation. The meanings are *assumed* to be clear, so the departure from SOP is in most cases harmless. However, that is exactly what cockpit standardization is all about – trying to eliminate the need to make unnecessary assumptions during high-risk operations. The difficult question, of course, is where to draw the line. Unfortunately, the absolute distinction between what is humour and what is a deviation from SOP depends on the outcome. If this humour caused a breakdown in communication that led to an incident, then it would be labelled 'deviation from SOP'. If it did not result in an untoward consequence, it could be regarded as humour.

  Nonetheless, we take the position that these are still breaches in cockpit discipline that should not be taken lightly, as the following example illustrates. We once observed a take-off in which the captain was the pilot flying. The first officer was supposed to make standard airspeed calls of V-1, V-r and V-2. Instead, he combined the first two into a non-standard call of 'V-one-r', and at V-2 called 'two of 'em.' Obviously, the captain knew what was meant by these strange calls, and while one cannot say that this was a dangerous compromise with safety, it did represent a serious departure from SOPs. Perhaps worse, it established an atmosphere of tolerance on the part of the captain of sub-standard performance which may lay the groundwork for more serious SOP departures later.

We may question what moved the first officer to depart from standard procedures and utter nonsensical callouts. This example could of course be attributed as well to complacency, and as explained above. The link may be that complacency induces the introduction of 'humour' in place of standardization. But during a critical phase of flight operations is probably not an appropriate arena for too much humour.

Perhaps the appropriateness of humour on the flight deck is an area addressable by Crew Resource Management (CRM). It might be a relatively simple matter for the captain, during his initial briefing, to advise the subordinate crew member(s) on how he feels about humour in the performance of duties. It might be somewhat more difficult, in spite of the fact that CRM training stresses free two-way communication in the cockpit, for the other crew persons to do the same for a 'humorous' captain.

- *Frustration.* Pilots may feel that they have been driven to non-conformity by frustrating forces beyond their control. An example would be the failure to use the oxygen mask (above FL 250) when one pilot leaves the cockpit of a two-pilot aircraft. Our impression is that there is low conformity to this regulation, and the reason is equipment-induced. First, it is not comfortable to wear any mask, and furthermore, in some modern aircraft, it is difficult to replace the new inflatable masks in their receptacles. Pilots find it a frustrating task and avoid it by simply not conforming to the regulation.

  We observed an interesting ploy to overcome the mask while still obeying the regulation. In a two-pilot aircraft with the inflatable mask, the captain left the cockpit briefly while the aircraft was climbing unrestricted to FL 330. At about FL 200 the first officer called ATC and requested level off at FL 250, which he maintained until the captain returned, and then requested continuation of his climb. The mask is not required at this altitude. In this case the pilot conformed to the regulation and procedure, but possibly at some cost to the company (wasted fuel resulting from sub-optimal climb profile) and possibly also to the ATC system.

Technique The use of technique in the cockpit allows the pilot to express individualism and creativity without violating procedural constraints. A

technique may be defined as a personal method for carrying out a task. If the technique is consistent with the procedure, then the task is conducted correctly, and Δ is zero.

Techniques have been developed by pilots over their years of experience of flying various aircraft. Every pilot carries with him a virtual catalogue of techniques. They are often fine points which pilots have discovered for themselves, experimented with, or learned from other pilots. Consider the following technique: the Quiet Bridge visual approach to runway 28R at San Franciseo (SFO) requires a profile descent with fixes at 6000 ft 18 DME, 4000 ft 13 DME, and recommended 1900 ft 6 DME from the SFO VOR. We once observed a crew that, in preparation for this approach, built these fixes into the FMC and named them '6000', '4000', and '1900' (in an A-320 FMC it is possible to give any name for a 'man-made' waypoint, as opposed to 'SFO01', etc. in other FMS aircraft). As they flew this approach using only the autopilot and manual flying, the depiction of these fixes and their associated names (altitudes) on the map display provided an enhanced situation display.

Why does the procedure writer not include the techniques as part of the procedure? Generally this is not advisable: the techniques are too fine-grained. If SOPs were replaced with the detailed descriptions necessary for one to carry them out, the flight operations manuals would be many times their present size. The company should be happy to specify the procedure, and leave it to the individual pilot to apply what he/she considers the best technique.

To the credit of the flying profession, pilots are always looking for a better technique. The motivations are various: professional pride, overcoming boredom, expression of individuality, the comfort of the passengers, and perhaps most salient, a feeling that they can find a better way. Note that some of the motivations are the same as those that led to deviant behaviour and Δ, but in the case of techniques, they led to a more favourable result. Thus we see that there is room for flexibility and individualism even within a rigid procedurization and standardization.

We would add one caution regarding technique. Any given technique may indeed conform to the written procedure and thus not add to Δ, but would still entail an unnecessary risk. Although Δ is not increased time after time when this technique is employed, the seeds of a latent error may be planted. Therefore, within the context of our four 'P' framework, it is not enough for the technique to conform to the procedure; it must also be consistent with policies. If the technique is not consistent with both the published procedure and the published policy, calling it a technique means nothing – it is simply a deviation from SOP.

- *Automation and Technique.* The introduction of cockpit automation has brought a plethora of techniques, largely consisting of ways in which the pilots chose to employ the automatic devices and modes. These techniques are the result of the great variety of ways that a task can be accomplished in a high-technology aircraft, due to its many modes and options.

A common example is the automatic level-off manœuvre. Many pilots feel that left to its own, the auto-levelling produces flight manœuvres that are safe and satisfactory, but could be smoother and more comfortable for the passengers. Pilots also believe that in the auto-level-off manœuvre the autothrottles are too aggressive. As a result of this, many have developed techniques to smooth these actions; most of these techniques involve switching autopilot modes during the level-off. We emphasize that these are *techniques* and not procedures. They represent the superimposition of the pilot's own way of doing things upon a standard procedure, and as long as the SOP is not violated, it may be all to the good.

Pilot technique is actually accommodated by some modern flight guidance systems. The bank angle limiter, for example, invites the crew to express their preference for maximum bank angles and rates of turn, consistent with the demands of ATC, and the comfort of their passengers.

Other techniques have been developed to 'trick the computer', as Wiener discussed in his 1989 report on glass cockpit human factors. For example, the pilot of a glass cockpit aircraft, wishing to start a descent on VNAV path earlier than the displayed Top of Descent (TOD) point, could either enter a fictitious tailwind into the flight guidance computer, or could enter an altitude for turning on thermal anti-ice protection (which he had no intention of actually doing). Both methods would result in a recomputation of the TOD and VNAV path, with an earlier descent. Why would the pilots do it? Because experience had taught them that the correctly computed VNAV path would result in speeds that would require the use of spoilers, which pilots consider as unprofessional, as well as creating vibration that would discomfort the passengers.

Perhaps the most unusual technique we have observed was demonstrated by a captain of a B-757. Acting as Pilot Not Flying (PNF), he tuned the arrival ATIS on the VHF radio, listened to it, and then rather than writing it on a pad or a form, he proceeded to encrypt it into the scratch line of the Control Display Unit (CDU). He then read it from the CDU to the pilot flying. This was a captain who obviously wanted to make maximum use of his

automated devices. Of course, this method of recording the ATIS has its limitations, the most severe being that only one person in the world could decode the message as recorded. Still we must presume that this was a technique and not a procedural deviation, unless the company's manual said that the ATIS was to be written out by 'pen and pencil'.

Regardless of whether this was or was not a technical violation of company policy, it did seem to violate common sense, that ATIS information should be available to all pilots. What would we have thought if the captain had scribbled the ATIS on a form so illegibly that the first officer could not read it? Furthermore, had a message come into the scratch line, the ATIS message would have been lost. As we have previously said about individuality and humour, technique has its place. It may also have its price.

- *Management's view of technique.* What view should management take of pilots developing their own techniques? Does the superimposition of 'personal' technique on SOPs represent a compromise with standardization? Once again the answer is to be found in the four 'P's. Management must develop a philosophy that governs the freedom of the pilot to improvise, and from this philosophy will flow company policies that will state exactly what the company expects on the line. Our own view is, of course, to return to the definition of Δ. If the techniques employed on the line lead to practices that are consistent with the procedure and the policy, then Δ is zero and management should take little notice of the techniques employed.

  If management discovers, through standardization and quality management techniques, or the feedback loop (to be discussed next) that certain techniques may have potential for procedural deviation, then this can be dealt with through the normal quality assurance processes. It is entirely possible that the opposite could occur, that the quality management or feedback processes could discover superior techniques that should become procedures. Check-airmen play a vital role here. While their job is generally quality assurance and standardization, they should be watchful for line-generated techniques that could and should be incorporated into the company's SOPs.
- *Technique and CRM.* Our discussion of technique has centred on the means of executing company-generated cockpit procedures. The same principles apply to the vast and ill-defined area known as cockpit resource management (Wiener *et al.*, 1993). Pilots develop communication, team-building, stress management and

other mechanisms for getting the job done effectively. These can also be viewed as techniques, personalized ways of carrying out procedures. CRM training programmes attempt to teach principles of communication, not techniques. Just as in cockpit techniques, these are developed, largely by trial and error, as well as observations of others, during a pilot's experience. We have all seen examples of good and bad communications techniques in the cockpit and elsewhere. We can again apply the definition of Δ. If one's personal CRM techniques lead to congruence between policies, procedures and practices, they should be considered adaptive. If not, they generate Δ and must be dealt with through the same quality management mechanisms that are invoked by unsatisfactory piloting. We extend the comments of the last section to CRM as well: check-airmen should be vigilant in observing adaptive and maladaptive CRM techniques on the line and in training.

The hazards of tricking the computer combined with poor crew coordination can be seen in the following ASRS report.

> We were cleared to cross 40 MN west of LINDEN VOR to maintain FL 270. The captain and I began discussing the best method to program the CDU to allow the performance management system to descend the aircraft. We had a difference of opinion on how best to accomplish this task (since we are trained to use all possible on-board performance systems). We wanted to use the aircraft's capabilities to its fullest. As a result, a late descent was started using conventional autopilot capabilities (*vertical speed, maximum indicated mach/airspeed* and *speed brakes*). Near the end of the descent, the aircraft was descending at 340 knots and 6000 fpm. The aircraft crossed the fix approx. 250–500′ high . . . . This possible altitude excursion resulted because: 1) captain and F/O had differences of opinion on how to program the [FMC for] descent. Both thought their method was best: the captain's of programming (fooling) the computer to believe that anti-ice would be used during descent, which starts the descent earlier. The F/O's of subtracting 5 mile from the nav fix and programming the computer to cross 5 mile prior to LINDEN at FL 270. 2) Minor personality clash between captain and F/O brought about by differences of opinion on general flying duties, techniques of flying, and checklist discipline. 3) Time wasted by both captain and F/O (especially F/O) in incorrectly programming CDU and FMS for descent, which obviously wasted time at level flight, which should have been used for descent (ASRS Report No. 122778).

Standardization

Standardization is the palace guard of procedures. It is a management

function which begins with the writing of procedures, to ensure that they are consistent with the first two P's (philosophy and policies), are technically correct, and are published in a manner that will be clear to the line pilots. Standardization also extends to the various quality assurance methods that allow flight management to monitor line performance, training performance (of both instructors and trainees), and to guarantee conformity to SOPs (low values of Δ). These methods include recurrent training, LOFT, line checks, and simulator checkrides. We have stated previously in this chapter the vital role of standardization personnel as elements in the feedback loop which links the line to flight management, this we shall now discuss.

Feedback

We stress the importance of the feedback process. Feedback is an essential process because this is not a perfect world, and some procedures are not perfectly designed and this may lead to deviations on the part of the operators.

The frustration of a crew member who feels that management is unresponsive to feedback from the line can be seen in the following ASRS report:

> I am very concerned about the safety of the company's new checklist policy. The climb checklist has three different segments and it is not completed until about 18 000 feet. The approach checklist has a descent check that precedes it. The landing check has four segments. The 'landing check' is called after the approach flap settings. The 'landing gear' call stands alone, and the final segments are completed after the final flaps are set. The last segment requires both pilots to watch the flaps come down, no matter how busy an approach [we are flying]. We have had several major checklist changes over the last two years. This latest one is the most radical. Having flown with 20–30 F/Os using it, I find that about 30 to 40 percent of the time we are able to do all the checklists correctly. Since it takes so long to complete all the segments of the list, something usually gets left out. Many times it's the 'gear down' check, since it no longer is 'gear down/landing check' as we have all done since day-one in our careers. Also much of the check is done with a flow that does not match the checklist. After time off yon have to re-memorize the flow since it's so different from the list. I note that when a situation is tight we are all, at times, reverting back to some of the calls from the previous procedures. Even the new hires who never used another checklist are not able to remember all the steps. The company imposed the procedures without input from the line, and is not interested in our input. Please help us convince the company that these procedures are not user friendly before someone makes a serious mistake (ASRS Report No. 155183).

As we have noted, one of the reasons why pilots deviate from accepted procedures (create positive Δ) is that they think that they have a better way. In some cases they might. This view of Δ portrays it as a negative feedback signal in a closed-loop system. If a corrective path is available, ideally Δ will be a self-eliminating quantity.

One way of promoting conformity to procedures is by providing a formalized feedback between the operational world and flight management. Some may argue that this is not necessary and that flight management *is* part of the operational world. On the other hand, the performance of line pilots is the ultimate measure of the adequacy of procedures because of their daily interaction (and sometimes confrontation) with procedures. When written procedures are incompatible with the operational environment, or have technical deficiencies, or increase workload, or create conflicts in time management, etc., flight crews may react by resisting and deviating from SOP. This can be minimized by establishing a clear feedback path that will provide a channel of communication between the line and management. If the line pilot is resisting certain procedures, or if s/he feels that there is a better way, clearly this information should be brought to the attention of the procedure writers in management for reevaluation.

One value of a well managed feedback loop is to eliminate the difference between what is taught in the training centre and what is expected on the line. The oft-expressed instruction 'I don't care what they are teaching you in the simulator and ground school, this is how we do it on the line' reveals not a minor quirk, but a serious management and training failure.

We have used the word 'formal' to describe the desired feedback path. By this we mean that a clear mechanism be established for movement of information and suggestions from the line to management. Bland statements from management such as 'my door is always open,' or 'you can always go to your chief pilot' do not constitute a sufficient feedback path. The line pilot must feel that his input is desired, and will be taken seriously. Offhand comments given in passing in the corridors and coffee shops do not qualify as effective feedback mechanisms.

Discussing the feedback path from line to management forces us to consider briefly labour–management relations at airlines. To be successful, the feedback process must involve the participation of the appropriate pilots' representative group. At most carriers this would be the Air Line Pilots Association Safety Committee, or perhaps other committees such as Training or Professional Standards. The feedback path then would consist of a communication from the line to the representative group, and thence to management. This has some advantages over direct pilot-to-management communication, in that the pilot may wish for various reasons to be insulated from his managers. Also, by working through a committee, patterns can be noted by the committee members.

For this system to be effective, it is essential that a cooperative, non-adversarial relationship exist between management and the representative group. This is sometimes difficult when either contract negotiations are underway, or for whatever reason tensions exist between pilots and management. The feedback process can be effective only if management makes it clear that they are eager to receive input from the pilots' representative group on a non-adversarial basis, and the pilots' group in turn must resolve to stick to its safety mandate, and not be tempted to use safety as a smokescreen for contractual/industrial matters. It is a measure of the maturity of the management of both the company and the union if both sides can transcend 'politics as usual' for the sake of promoting safety.

We recommend that a clear, well-defined feedback loop be established and supported so as to provide an effective channel of communication between line and management. To be effective, the feedback process must be easy to use, non-threatening, and above all must engender at least the promise that the line pilot can affect something.

Conclusions

We believe that the four 'P's concept detailed in this chapter forms the foundation for writing and enforcing flight deck procedures in a consistent and logical manner, within and across fleets. Consistent and technically correct procedures in turn ensure both the economical utilization of humans and equipment and the safe conduct of flight. Any procedure, even the best one, cannot be 'bullet-proof'. It can only be a baseline. The role of management should be to provide the best possible baseline for its crews, and then train and standardize to this baseline. No procedure is a substitute for an intelligent operator.

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Appendix 1 – Delta Air Lines automation philosophy statement

The word 'Automation', where it appears in this statement, shall mean the replacement of human function, either manual or cognitive, with a machine function. This definition applies to all levels of automation in all airplanes flown by this airline. The purpose of automation is to aid the pilot in doing his or her job.

The pilot is the most complex, capable and flexible component of the air transport system, and as such is best suited to determine the optimal use of resources in any given situation. Pilots must be proficient in operating their airplanes in all levels of automation. They must be knowledgeable in the selection of the appropriate degree of automation, and must have the skills needed to move from one level of automation to another.

Automation should be used at the level most appropriate to enhance the priorities of Safety, Passenger Comfort, Public Relations, Schedule, and Economy, as stated in the Flight Operations Policy Manual.

In order to achieve the above priorities, all Delta Air Lines training programs, training devices, procedures, checklists, aircraft and equipment acquisitions, manuals, quality control programs, standardization, supporting documents, and the day-to-day operations of Delta aircraft shall be in accordance with this statement of philosophy.

(Reprinted from Wiener *et al.*, 1991, p. 146.)